Turbo Code Carrier Synchronization Losses (Radio Losses)

by

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Turbo Codes offer an attractive alternative to concatenated codes for deep space telecommunications due to their high performance. However, before such codes could be implemented for use with deep space missions, the effects of demodulation on their performance should be evaluated. For standard deep space telecommunications, typically the step that produces the largest amount of performance degradation for channel codes is carrier synchronization. Therefore, the focus of this paper is to quantify the losses associated with that process (the so-called radio losses) for Turbo Codes.

In this, paper we evaluate the losses for four types of Turbo Codes recommended by CCSDS: (8920,1/3), (8920,1/6), (1784,1/3) and (1784,1/6). This is done by simulating the effects of synchronization with both a phase locked loop and a Costas loop (similar to ones used in Deep Space Network's Block V Receivers) on these codes. These radio losses are calculated for specific frame error rates. For (8920,1/3) and (8920,1/6) codes this frame error rate is 3×10^{-4}. For (1784,1/3) and (1784,1/6) the selected frame error rate is 6×10^{-5}. These frame error rates were selected so that the output bit error rate performance of these codes will be comparable. The phase locked loop simulations are used to obtain radio losses for residual carrier modulation cases. For these simulations, loop signal to noise ratios of 13dB, 15dB and 17dB were used. In each case the data rate was varied and at each data rate the radio losses were calculated for each code. The Costas loop simulations are used for evaluating radio losses for suppressed carrier modulation. For these simulations, a loop signal to noise ratio of 17dB was used as this is the minimum loop signal to noise ratio under which suppressed carrier communication is feasible. Again, for these simulations, the data rate was varied and the radio loss at each data rate was obtained for each code.

The results of these simulations indicate that the radio losses for turbo codes are reasonably low (maximum of 1dB loss at 17dB loop signal to noise ratio for residual carrier and 1.3dB loss at 17dB loop signal to noise ratio for suppressed carrier at high data rates) to warrant their use in deep space links. Furthermore, the results indicate that by normalizing the radio losses for frame size, loop bandwidth and the loop signal to noise ratio, a single curve could be used for calculating the radio loss for any given data rate at any given loop signal to noise ratio.